COMPARISON OF CHEMICAL ABSORBENTS USED FOR CO_2 CAPTURE IN COAL-FIRED POWER PLANTS

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1. Introducción

Climate change conference was hold in Copenhagen in 2009, global warming became the worldwide focus once again. China as a developing country has paid more attention for this environmental problem. In China, a large part of carbon dioxide is emitted to the atmosphere from combustion of fossil fuels in power plants. How to control emission of the greenhouse gas into atmosphere is becoming an urgent concern. Among numerous methods, CO_2 capture is the hope to limit the amount of CO_2 emitted into the air. The well-established method for CO_2 capture is to remove CO_2 by absorption into solutions in conventional equipment. Absorbents used for CO_2 and H_2S capture are important choice for CO_2 capture technology. It is related to the cost and efficiency of plant directly and is essential to investigate the proposed CO_2 and H_2S absorbents.

2.Experimental

A thermodynamic and economic comparison [1] of aqueous solutions of piperazine (PZ) promoted potassium carbonate (K_2CO_3) and monoethanolamine (MEA) based on fair boundary conditions and constant assumptions using rigorous thermodynamic models is described.

Table 1: Thermodynamic results

	7 m MEA	$K_{2.5}P_{2.5}$	$K_{3.2}P_{1.6}$
Desorber pressure(bar)	2.1	2.4	0.5
Reboiler temperature(℃)	121	131	88
Optimal L/G	2.9	16.5	12.1
Lean loading(mol CO_2^{tot}/[mol solvent])	0.220	1.005	1.115
Rich loading	0.555	1.096	1.243
Pick-up range	0.335	0.091	0.128
Spec. reboiler duty(GJ/t CO_2)	3.16	3.30	3.63
Heat duty capture(MW_{th})	622	651	716
Power duty capture(MW_{el})	20.7	23.5	22.1

Power duty compression(MW_{el})	54.2	53.7	70.5
Cooling duty capture(MW_{th})	1115	1150	1220
Cooling duty compression(MW_{th})	95.1	94.4	113.3

In a part of the EU project CASTOR, [2], three different amine solvents 30%-weight MEA, CASTOR1 and CASTOR2 have been tested for four 1000-hours test campaigns.
ASPEN simulations of a carbon-dioxide (CO_2)removal and recovery plant that captures CO_2 from a 500 MWe(net) conventional coal-fired power plant flue gas stream[3] has been carried out showing that at a constant CO_2 recovery rate of 86.5% by weight, the performance of aqueous ammonia solution as an alternative to various aqueous amino solvents (MEA, AMP and MDEA) is compared in terms of the process scenarios, solvent loadings and overall energy consumption.

2. Results and discussion

After studied those researches above, some conclusions are summarized below:
(1)Among these CO_2 removal techniques, absorption into a liquid solvent is the most suitable process for high volumes of synthesis gas stream. Chemical solvent MEA is considered the first solvent to be used in large-scale applications of post-combustion CO_2 capture in coal-fired power plants because it has good characteristics such as fast absorption rate to carbon dioxide, easily available chemical and relatively high boiling point. However, the major problem caused by the use of MEA as an absorbent in post-combustion manner is that MEA could require high energy consumption at the stripping stage. Some researches have been carried out to solve this problem, some absorbents are indeed found to have lower energy consumption compare to MEA, therefore, other properties are not sure to be better or even equal to MEA. In conclusion, MEA is still considered to be the first solvent; no certain solvent can replace MEA at present.
(2)H_2S removal is an important technology in IGCC. Cold gas cleaning systems have been used for years but it had several disadvantages, such as significant cycle efficiency penalty, loss of steam and high capital costs. Metal-based sorbents like Zn-based sorbents, Carbon-based sorbents have been investigated recently.

3. References

[1] Jochen Oexmann, Alfons Kather. Post-combustion CO_2 capture in coal-fired power plants: comparison of integrated chemical absorption processes with piperazine promoted potassium carbonate and MEA (2009) 432-439
[2] Jacob N. Knudsen, Jogen N. Jensen, Poul-Jacob Vilhelmsen, Ole Biede. Experience with CO2 capture from coal flue gas in pilot-scale: Testing of different amine solvents. Energy Procedia 1 (2009) 783–790
[3] N.Dave, T.Do, G.Puxty, R.Rowland, P.H.M.Feron, M.I.Attalla. CO_2 capture by aqueous amines and aqueous ammonia-A Comparison. Energy Procedia 1 (2009)949–954